

15597
Vitrophyric Pigeonite Basalt
 145.7 grams



Figure 1: Exposed surface of 15597 showing numerous micrometeorite craters. Sample is 7 cm across. NASA S71-44457.

Introduction

Lunar sample 15597 was collected from the soil near the edge of Hadley Rille in an area called The Terrace (see transcript). It has a texture similar to the boulder sampled nearby (see 15595). The “plagioclase clusters” that the CDR (Scott) described on the surface, are, in fact, large pigeonite phenocrysts. The surfaces of 15597 are covered with zap pits (figure 1).

15597 is thought to be an important lunar sample, because it was quenched from high temperature giving important insight to the crystallization history and cooling rate of lunar basalts. Its bulk composition has also been interpreted as that of primary undifferentiated liquid formed by partial melting at depth and giving information of the lunar interior. Ryder (1985) presents an excellent review of the petrology of 15597.

Petrography

Weigand and Hollister (1973) described “sample 15597 as a pyroxene vitrophyre (figures 2 and 3) consisting mainly of acicular pyroxene phenocrysts, typically with a glass core, set in a matrix of brown glass which shows incipient crystallization in only a few places. The texture is locally variolitic. The pyroxene crystals are composed of a pigeonite center epitaxially rimmed by

TRANSCRIPT

CDR . . . Let's go down and get a chunk of the bedrock here.
LMP Oh, you're getting the bedrock here, huh?
CDR Yes
LMP Okay. I thought you were going to press on to the north.
CDR Well, he said go get the bedrock, and I think we ought to try and get it if we can. Because this sure looks like bedrock to me. I looked at the rille and down the rille to the south, and it's just one great big massive layer of the same type of fragmental debris on the order of meters. Quite well-rounded.
LMP Yes, but the thing that bothers me, Dave, is look to the north there, it looks like int might be the top of the bedrock. And those blocks are – seem to be slightly different.
CDR Darker. - - - A little darker.
LMP - - - almost have columnar jointing. Look to the north there.
CDR Yes, I see what you are talking about. Come on down here and let's get a frag off of one of these boulders and then we'll head on back to the rover. - - That's a good one - - -Hey, Joe, these rounded fragments down here are on the order of meters in

Mineralogical Mode of 15597

	Catalog Butler 1971	Papike et al. 1976	Weigand and Hollister 1973
Olivine			
Pyroxene	59 %	50.1	59
Plagioclase			
Opaque	0.3	<0.1	1
Groundmass	41	49.9	
Glass			35

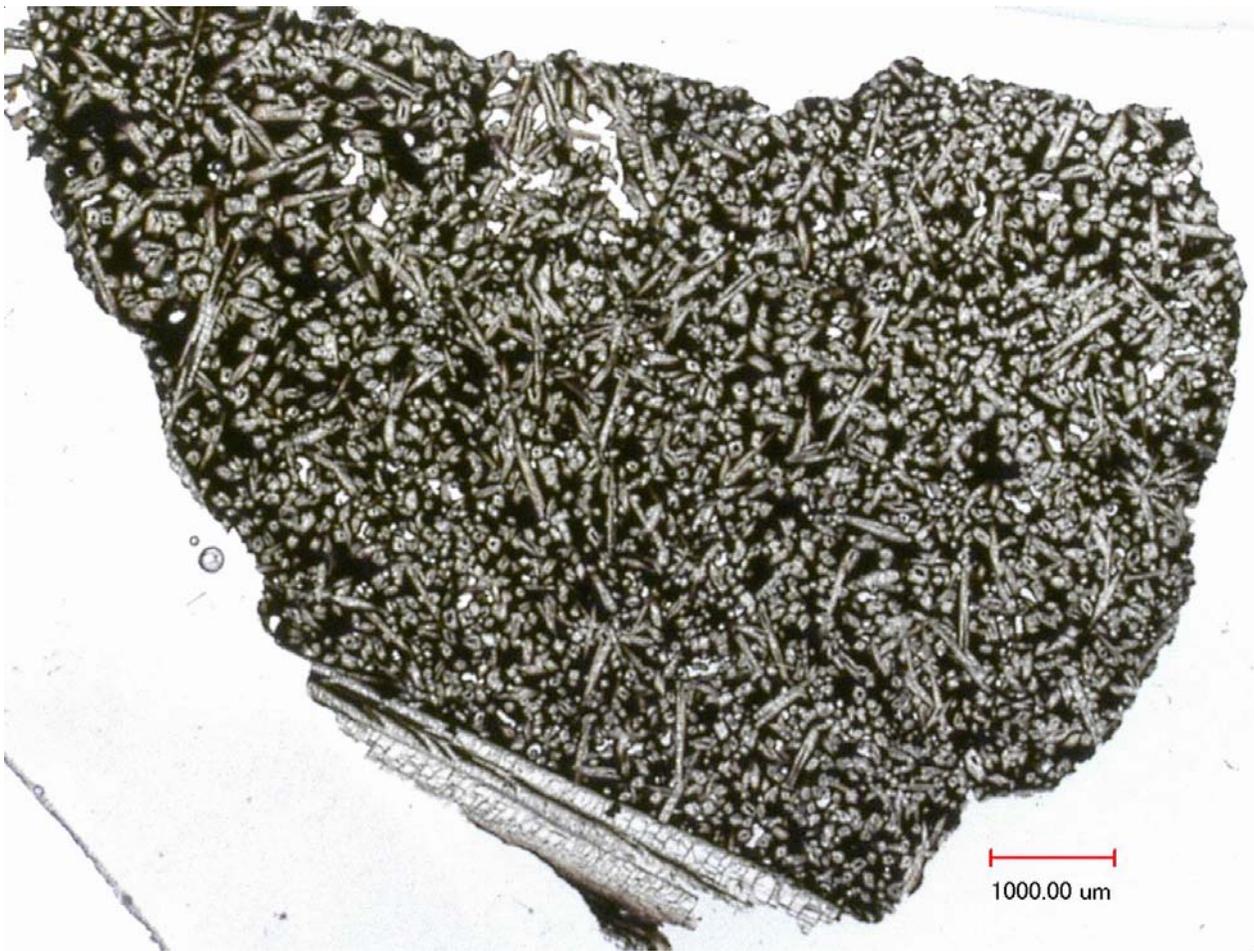


Figure 2: Photomicrograph of thin section 15597,12 by C Meyer @ 30x.

augite. Scattered chromium spinel euhedral and native iron globules also occur. Vesicles range in size from a few tens to ~ 500 microns.” Drever et al. (1973) and Donaldson et al. (1977) described and explained the importance of radiate texture of pyroxene showing that they are not accumulations, but the result of rapid cooling. Other vitrophyres found at Apollo 15 include 15595, 15596, 15485, 15486 and 15499.

The bulk composition of 15597 was used for numerous experimental studies (Grove and Bence 1977; Grove and Raudsapp 1978; Grove and Lindsley 1979).

Residual glass has very high Fe/Mg ratio.

The cooling rate of 15597 has been much discussed (Lofgren et al. 1974, 1975 and 1979; Grove and Walker 1977; Donaldson et al. 1977; Grove 1982)

size; expose some very large – oh, – 3 cm vesicles – rather than the finer stuff that Jim saw back there before.

CDR And I believe, when I take a chip out of this, we’re going to find it’s the same kind of crystalline basalt. And they’re all – well, they’re subangular – looks like they’ve been weathered. Fairly clean on the surface and all buried. And I can look down to the south, and it’s just a whole mass of great big boulders along the terrace here. And there’s another breakoff down into the rille. And I’m – I guess, we’re just about at the lip. - - - Beautiful stuff. Okay: I got them all loaded in the bag (15595, 15596?).

CDR Okay. This is a - looks like a darker, fine-grained, black, vesicular basalt, with vesicles on the order of mm. (15597?) Nonuniformly distributed. There are a mass of plagioclases about 3 mm long, and it may be a half a mm wide, randomly oriented throughout. And that’s about the only mineral I see. And that – did you get the number on that, Jim,?

LMP I gave it to them.

CDR There’s one other frag down there that fell. About like that. Let me get a couple of rounded ones, too, that are just on the surface. I can’t tell what that is, but we’ll put it in anyway, as representative of surface material – at least the fragmental surface. (15598?)



Figure 3: Photomicrographs of thin section of 15597. a) plane polarized, b) crossed polarized. NASA S 71-51793 and 51794. Scale about 1 x 2 mm.

Mineralogy

Olivine: Any early formed olivine (it is on the liquidus) has apparently reacted out.

Pyroxene: Weigand and Hollister (1973) and Grove and Bence (1977) studied major and trace element zoning in pyroxene (figure 4). It is unusual, because plagioclase and ilmenite did not have time to nucleate. Rim augite has high Al and Ti. Brown and Weschler (1973), Brown et al. (1973) and Grove (1982) studied the crystallography of pyroxenes in 15597 and synthetic experiments with controlled cooling history.

The first pigeonite to crystallize was Wo4En70Fs26 which zones outward to Wo15En52Fs33, where it jumps to Wo30En40Fs30 and continues to zone to Wo32En10Fs58.

Large crystals of pigeonite were seen in hand specimen (Butler 1972; Tanscript) and one is present in some of the thin section (figure 2 and 3). It has a wide core with constant composition, but since it is not as Mg

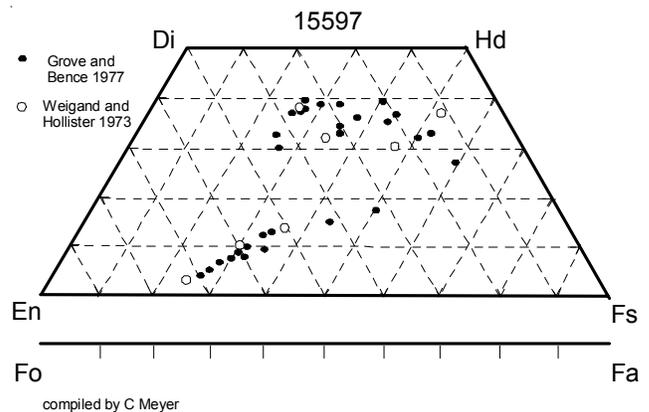


Figure 4: Pyroxene composition of 15597 (no olivine).

rich as some, it probably wasn't the first crystal to form (see Weigand and Hossister).

Plagioclase: none

Ilmenite: none

Chromite: Weigand and Hollister (1973) found that chromite grains had a "bimodal size distribution". The

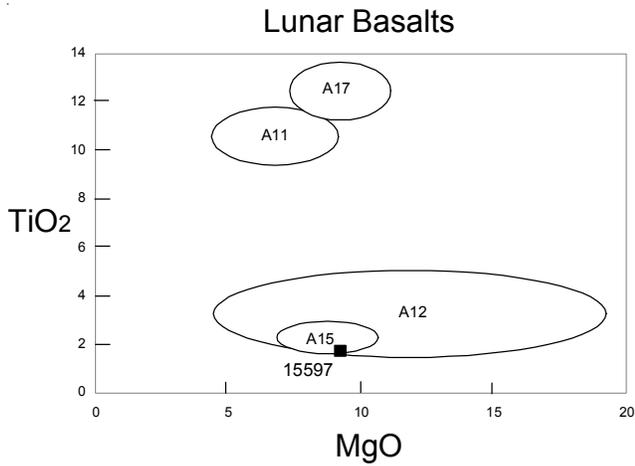


Figure 5: Chemical composition of 15597 compared with that of other lunar basalts.

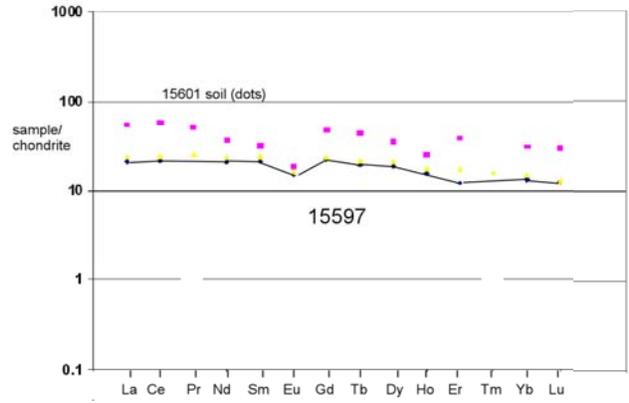


Figure 6: Normalized rare-earth-element diagram for 15597 (data by Helmke et al. 1973).

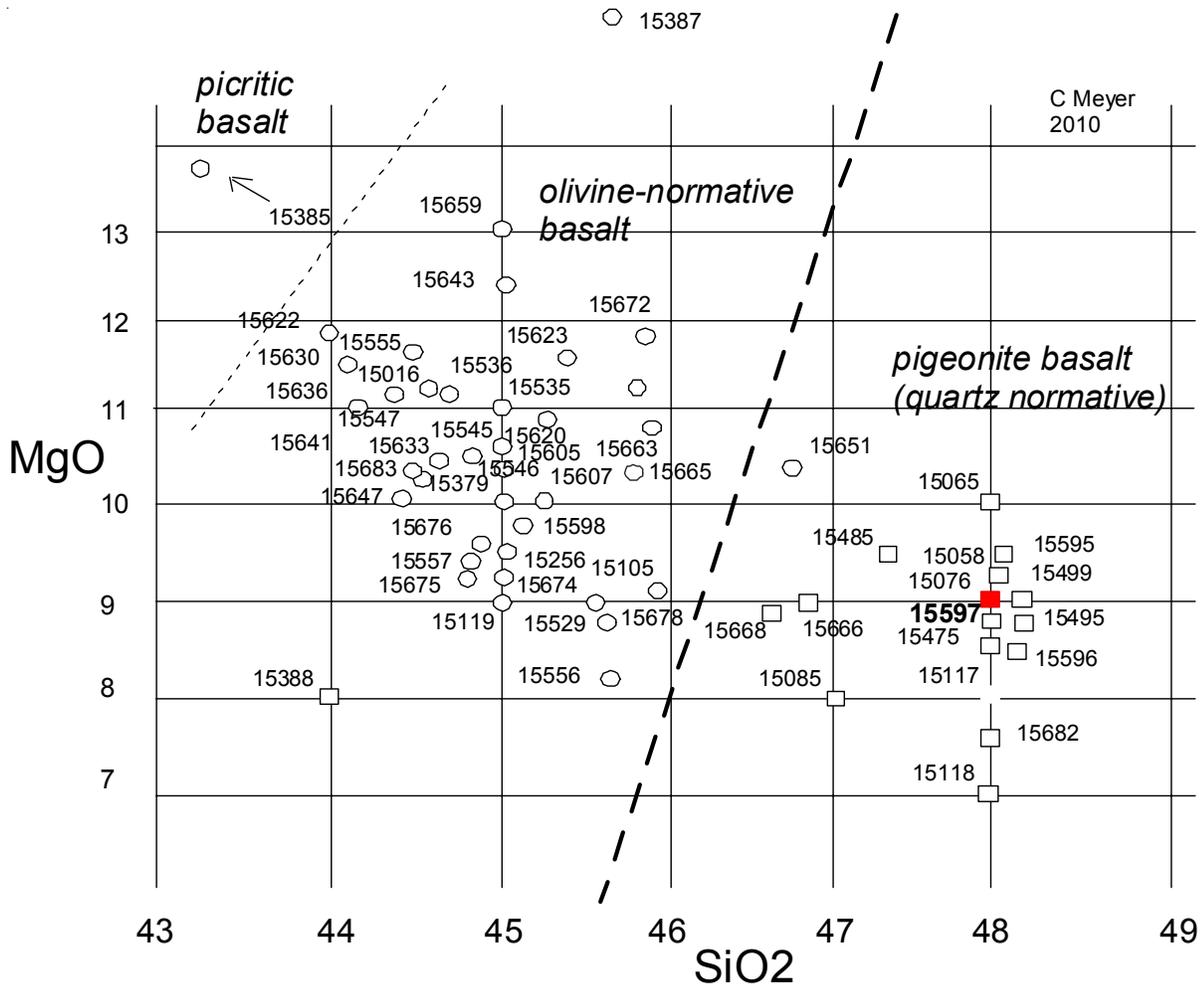
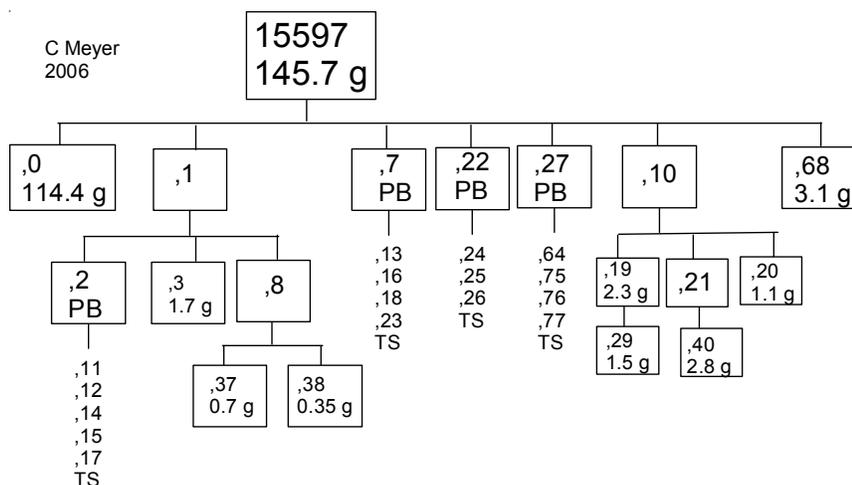


Figure 7: The big picture showing the composition of 15597 compared with other Apollo 15 basalts.

Table 1. Chemical composition of 15597.

reference weight	Chappel73	Helmke73	Nava75	3.8 g matrix	Ganapathy73 Wolf79	O'Kelley72
SiO2 %	47.98	(a) 48	(d) 48.1	47.9	(b)	
TiO2	1.8	(a) 1.84	(d) 1.87	2.3	(b)	
Al2O3	9.44	(a) 9.55	(d) 9.27	15.13	(b)	
FeO	20.23	(a) 20.6	(d) 20.17	22.24	(b)	
MnO	0.3	(a) 0.28	(d) 0.254	0.224	(b)	
MgO	8.74	(a) 9.06	(d) 9.18	1.4	(b)	
CaO	10.43	(a) 10.4	(d) 9.69	9.62	(b)	
Na2O	0.32	(a) 0.317	(d) 0.32	0.66	(b)	
K2O	0.06	(a) 0.078	(d) 0.056	0.111	(b)	0.053 (e)
P2O5	0.07	(a)	0.107	0.151	(b)	
S %	0.06	(a)				
sum						
Sc ppm						
V						
Cr	3284	(a)	3353		(b)	
Co				40		(c)
Ni		30	(d)			
Cu						
Zn				1.2		(c)
Ga	2.6	(a)				
Ge ppb				6.5		(c)
As						
Se				117		(c)
Rb	0.9	(a)		0.72		(c)
Sr	109.4	(a) 91	(d)			
Y	27	(a)				
Zr	101	(a)				
Nb	6	(a)				
Mo						
Ru						
Rh						
Pd ppb						
Ag ppb				0.9		(c)
Cd ppb				1.7		(c)
In ppb				0.59		(c)
Sn ppb						
Sb ppb				1.49		(c)
Te ppb				1.9		(c)
Cs ppm				0.04		(c)
Ba		52	(d)			
La		4.86	(d)			
Ce		13	(d)			
Pr						
Nd		9.3	(d)			
Sm		3.09	(d)			
Eu		0.84	(d)			
Gd		4.4	(d)			
Tb		0.69	(d)			
Dy		4.51	(d)			
Ho		0.86	(d)			
Er		1.9	(d)			
Tm						
Yb		2.13	(d)			
Lu		0.301	(d)			
Hf						
Ta						
W ppb						
Re ppb				0.0081		(c)
Os ppb						
Ir ppb				0.0072		(c)
Pt ppb						
Au ppb				0.045		(c)
Th ppm					0.53	(e)
U ppm					0.14	(e)

technique: (a) XRF, (b) AA, (c) RNAA, (d) INAA, (e) radiation counting



larger grains (~100 microns) were euhedral and found in “clusters”, generally within pyroxene. Where chromite grains are in contact with glass, they are rimmed with ulvospinel.

Metallic Iron: Weigand and Hollister (1973) reported that small Ni-Co-Fe grains nucleated early (Ni = 4 – 7%; Co 1 – 3%). Metallic iron is often found adjacent to chromite.

Chemistry

Chappell and Green (1973) determined the major element composition by XRF. O’Kelley et al. (1972), Helmke et al. (1973) and Ganapathy et al. (1973) determined trace elements (figure 6).

Radiogenic age dating

Kirsten et al. (1973) reported that 15597 had “large amounts” of excess Ar. Compston et al. (1972) determined the Sr isotopic composition.

Cosmogenic isotopes and exposure ages

Eldridge et al. (1972) determined the cosmic-ray-induced activity of $^{22}\text{Na} = 31$ dpm/kg, $^{26}\text{Al} = 88$ dpm/kg and $^{54}\text{Mn} = 30$ dpm/kg, Kirsten et al. (1973) reported a cosmic ray exposure age of 210 m.y. by ^{38}Ar and Alexander et al. (1972) determined the isotopic composition of Kr (exposure age not calculated).

Other Studies

Clayton et al. (1972) reported oxygen isotopes.

Hargraves and Dorety (1972) and Fuller et al. (1979) determined the magnetic properties.

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